PATENT SPECIFICATION

(11) 1 226 593

NO DRAWINGS

1 226 593

(21) Application No. 22422/68 (22) Filed 10 May 1968

(61) Patent of Addition to No. 1104690 dated 2 Sept. 1966

(31) Convention Application No. 965617 (32) Filed 10 May 1967 in

(33) Canada (CA)

(45) Complete Specification published 31 March 1971

(51) International Classification C 21 b 13/12

(52) Index at acceptance
C7D 3G1D 3G2A1 3G2B 3G4B 3G7C 3G7H2 3G7L 3G7M
3G7H2 3G7L 3G7M

(54) IMPROVEMENTS IN ELECTRIC-ARC STEELMAKING

(71) We, METALLGESELLSCHAFT AKTIENGESELLSCHAFT, a joint stock Company organised under the laws of Germany, of 14 Reuterweg, Frankfurt, (Main) 1, Germany, THE STEEL COMPANY OF CANADA LIMITED, a Company organised under the Laws of Canada, of Wilcox Street, Hamilton, Ontario, Canada, and PICKANDS MATHER & COMPANY, a Corporation organised under the Laws of the State of Delaware, United States of America, of 2000 Union Commerce Building, Cleveland, Ohio, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to electric arc steel making.

In our Patent No. 1,104,690 there is described a method of producing steel containing from 0.02 to 1.8% carbon from materials containing metallic iron, in an electric arc furnace, comprising forming a metal pool with a layer of slag thereabove in the furnace, and then continuously introducing iron-bearing material in small particulate form, into the layer of slag above the metal pool at a rate controlled by reference to the electrical power consumption of the furnace such that at the end of the introduction of the iron-bearing material the metal melt is substantially at the temperature required for tapping the furnace and possesses the desired carbon content.

If an inexpensive and plentiful supply of suitable scrap material is readily available, it may be preferred to use a minimum of sponge iron and as much scrap as practicable by the normally undesirable batch charging of the scrap; the continuously fed sponge iron being introduced to obtain the important advantage of minimizing the refining period as described in the above mentioned Patent No. 1,104,690. Therefore, although the process has proceeded with reference to the introduction of discrete particles of iron-bearing materials in the form of sponge iron to electric-arc furnaces in amounts of, for example, 63.5 per cent, 82 per cent and as much as about 100 per cent by weght of the total charge, it will be understood that the process can be carried out with a total continuously charged sponge iron content as low as about 15 per cent of the total charge which in practice is sufficient to substantially eliminate the conventional refining period. However, in heats made with low percentages of sponge iron, or of sponge iron having low residual oxygen contents, it is found that correction of the carbon content and/or bath agitation are required, and, according to the invention, these can be achieved through the use of oxygen lancing by blowing oxygen or oxygen-enriched air into the molten bath.

Accordingly the present invention provides a method of producing steel comprising initially charging an iron-bearing material and slag producing constituents into a refractory lined electric arc furnace, melting said iron-bearing material and slag producing constituents to form a metal pool with a layer of slag thereabove in the furnace, then continuously charging the furnace with iron-bearing material in small particulate form at a rate controlled by reference to the electrical power consumption of the furnace at least 15% by weight of the total charge being introduced to the furnace as particulate iron-bearing material and said particulate iron-bearing material containing from 76% to 99.5% by weight total iron and introducing oxygen into the molten bath by lancing oxygen or oxygen enriched air into the molten bath to correct the carbon content and/or effect agitation of the bath, the oxygen being so introduced during or after the charging of the iron-bearing material that the final metal melt substantially possesses the desired carbon content.

In carrying out the present method, the furnace electrodes are positioned in proximity to the initial charge and power is applied to the electrodes to direct arcs from

the electrodes to the initial charge to form bore cavities which consolidate therein to form a pool of metal having a slag layer. The particulate iron-bearing material is introduced into the furnace in proximity to arc flare locations and the refined steel is tapped from the furnace when the total energy consumption of the furnace is from 250 to 700 KWH/ton of iron-bearing material. The oxygen lancing serves either to correct the carbon content and/or effect agitation of the bath, and is preferably effected while the iron-bearing material is being charged.

The slag layer is preferably controlled such that the arcs from the furnace electrodes are immersed within the slag layer with no substantial direct radiation therefrom to the furnace lining, and this can be conveniently done by varying the electrical resistivity, fluidity, volume or density of the slag, the electrical resistivity being varied by maintaining the slag basicity within the average range of from 1.0 to 1.5. The rate of charge of iron-bearing material and slag fluidity should desirably be controlled to avoid the formation of clusters or unmelted material on the slag layer. The slag can be foamed during the continuous charging of the particulate iron-bearing material by charging particulate iron-bearing material of which at least 30 per cent is minus $^3/_{16}$ inch in size.

The initial charge will normally comprise scrap metal carbon, and fluxing and, optionally, alloying additives and the particulate iron-bearing material may comprise sponge iron, iron ore or iron oxide scale together with any necessary silica, carburizing and/or oxidizing constituents, the particulate iron-bearing material containing from 76% to 99.5% by weight total iron.

Some uncertainty with respect to carbon levels is inherent in the low percentage sponge practice because only a small portion of the sponge, with its known chemical composition, is used, and a reduction of carbon content may be necessary. Also, sponge iron having low residual oxygen contents provides a flat bath, and bath agitation, if desirable, may be effected by adding oxygen for reaction with carbon. The oxygen lancing preferably is carried out while the sponge iron is being charged so that the additional heat generated by the oxygen reacting with the bath carbon can be compensated for, by an increase in the sponge iron feed rate. The use of oxygen, therefore, leads to shortened heat times and to further reduced electrical energy requirements. Likewise, carbon additions can be made at intervals or continuously during the continuous charging of iron-bearing material to correct the carbon content of the bath if the carbon content should be too low.

The use of about 15 per cent discrete particles of iron-bearing material, while not overcoming some problems incurred in the bath charging of scrap material as described in Patent No. 1,104,690, provides the important advantage of substantially minimizing the refining period which normally takes place after the meltdown of conventional charges. Although, the addition of as little as 15 per cent discrete material such as sponge iron necessitates close control of carbon content, due to the uncertainty of composition of the scrap material, carbon control maintained by oxygen lancing provides exothermic heat which permits an increase in the rate of sponge iron addition and acceleration of the substantially concurrent melting and refining operations.

Agitation of the molten bath by reaction of carbon with oxygen promotes melting of charged materials and an accelerated refining operation substantially concurrent with the charging of discrete iron-bearing material. We have found that although iron-bearing materials having less than 0.1 per cent residual oxygen provide a flat bath of molten metal, which can hinder pellet solutioning in the slag layer, as indicated in Example 4 of Patent No. 1,104,690, agitation of the bath during continuous charging of the iron-bearing material is assisted by magnetomotive forces resulting from phase rotation.

In geographic areas where the quality of scrap is poor or otherwise not suitable for use in electric-arc steelmaking, it may be preferable to retain a portion of a preceding heat in the furnace to provide a molten bath into which the sponge iron can be charged. The molten metal comprising the heat can be recarburized by the addition of a carbon-containing material such as petroleum coke to provide a hot metal into which the sponge iron is continuously charged as had been described in Patent No. 1,104,690 with reference to Figure 5.

The slag basicity range for typical heats has been given in the above mentioned Patent No. 1,104,690 as 1.0 to 1.5. We have found that a slag basicity averaging within the range of 1.0 to 1.5, i.e. which initially is low but may increase above 2.0 during the latter stages of the heat, may be desirable for the refining of iron-bearing materials having high sulphur and phosphorus contents.

WHAT WE CLAIM IS:—

1. A method of producing steel comprising initially charging an iron-bearing material and slag producing constituents into a refractory lined-electric arc furnace, melting said iron-bearing material and slag producing constituents to form a metal pool with a layer of slag thereabove in the furnace, then continuously charging the furnace with iron-bearing material in small particulate

form at a rate controlled by reference to the electrical power consumption of the furnace, at least 15% by weight of the total charge being introduced to the furnace as particulate iron bearing material and said particulate iron-bearing material containing from 76% to 99.5% by weight total iron, and introducing oxygen into the molten bath by lancing oxygen or oxygen enriched air into the molten bath to correct the carbon content and/or effect agitation of the bath, the oxygen being so introduced during or after the charging of the iron-bearing material that the final metal melt substantially possesses the desired carbon content.

2. A method as claimed in Claim 1, wherein the furnace electrodes are positioned in proximity to the initial charge and power is applied to said electrodes to direct arcs from said electrodes to said initial charge to form bore cavities which consolidate therein to form a pool of metal having a slag layer, the particulate iron-bearing material being introduced into the furnace in proximity to arc flare locations and refined steel being tapped from the furnace when the total energy consumption of the furnace is from 250 to 700 KWH/ton of iron-bearing material.

3. A method as claimed in either preceding claim, wherein said slag layer is controlled such that the arcs from the furnace electrodes are immersed within said slag layer with no substantial direct radiation therefrom to the furnace lining.

4. A method as claimed in Claim 3, wherein said slag layer is controlled such that the arcs from the electrodes are immersed within said slag cover with no substantial direct radiation therefrom to the furnace lining by varying the electrical resistivity, fluidity, volume or density of the slag.

5. A method as claimed in Claim 4, wherein said electrical resistivity is varied by maintaining the slag basicity within the average range of from 1.0 to 1.5.

6. A method as claimed in any preceding claim, wherein the rate of charge of iron-bearing material and slag fluidity are controlled to avoid the formation of clusters or unmelted material on the slag layer.

7. A method as claimed in any preceding claim, wherein agitation of the bath during continuous charging of the particulate iron-bearing material is assisted by magnetomotive forces resulting from phase rotation.

8. A modification of the method claimed in any preceding claim, wherein said bath of molten metal is formed by retaining a portion of a preceding heat in the furnace.

9. A method as claimed in any preceding claim, wherein said slag is formed during continuous charging of the particulate iron-bearing material by charging particulate iron-bearing material of which at least 30 per cent is minus $^3/_{16}$ inch in size.

10. A method as claimed in any preceding claim, wherein the furnace is initially charged with scrap metal, carbon, and fluxing, and, optionally, alloying additives.

11. A method as claimed in any preceding claim, wherein the particulate iron-bearing material is sponge iron, iron ore or iron oxide scale together with any necessary silica, carburizing and/or oxidizing constituents.

12. A method of producing steel substantially in accordance with Claim 1 as described herein.

13. Steel produced by the method as claimed in any preceding claim.

TREGEAR, THIEMANN & BLEACH,
Chartered Patent Agents,
Melbourne House,
Aldwych,
London, W.C.2,
Agents for the Applicants.

(8086) Printed by Her Majesty's Stationery Office Press, Edinburgh, 1971.
Published by The Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.